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ABSTRACT

This study was directed towards developing microfiche formatting concepts and microfiche production methods to capture the power of the medium for the delivery of both text and illustrations within the context of the Advanced Instructional System (AIS)--a computer based, multi-media, self-paced instructional program of the Air Training Command at Lowry AFB, Colorado. Specific applications were (1) the conversion of color intensive audiovisual modules to microfiche; (2) the formatting of the microfiche to deliver both primary and alternative track modules in an integrated multi-track module, and (3) the use of microfiche in testing and test control. A primary consideration was the investigation of computer output microfiche (COM) technology as a means of authoring, revising, and managing instructional materials. A microfiche system was designed, utilizing existing AIS computer resources, which satisfied administrative as well as instructional requirements. Applications were then developed in which specific AIS lessons were formatted for multi-track, color intensive presentation on microfiche. In addition, block tests were produced using COM production techniques. Based on classroom evaluations, results suggest that the Dual-Fiche concept charts a path that promises to be a cost-effective alternative to existing AIS instructional media, as well as a means of routinely updating and revising instructional modules that combine text and graphics. Appendices contain questionnaires used for implementation feedback. (Author/CHV)

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MICROFICHE APPLICATIONS IN AN INDIVIDUALIZED, SELF-PACED LEARNING SYSTEM

By

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The microfiche medium offers proven advantages in the management, storage, and retrieval of information, as well as significant cost advantages. The study was directed towards developing microfiche formatting concepts and microfiche production methods to capture the power of the medium for delivery of both text and illustrations within context of the Advanced Instructional System (AIS)—a computer based, multi-media, self-paced instructional program of the Air Training Command at Lowry AFB, Colorado. Specific applications were (a) the conversion of color intensive audiovisual modules to microfiche; (b) the formatting of the microfiche to deliver both primary and alternative track modules in an integrated "multi-track" module, and (c) the use of microfiche in testing and test control. A primary consideration was the investigation of computer output microfiche (COM) technology as a means

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of authoring, revising, and managing instructional materials. A microfiche system was designed, utilizing existing AIS computer resources, which satisfied administrative as well as instructional requirements. The system is called the dual-fiche concept and provides a way to separate the production of the text component of an instructional module from the production of the graphics component, combining the two types of information at the point of use–the microfiche reader. This development brings the power of COM to bear directly on the problems of updating and revising instructional materials while gaining the flexibility necessary to produce graphics (particularly color-intensive graphics) consistent with content formatting requirements. The concept involves two transparencies (one with text and the other with graphics) which are projected simultaneously.

Applications were then developed in which specific AIS lessons were formatted for multi-track, color intensive presentation on microfiche. In addition, block tests were produced also using COM production techniques. Classroom trials were conducted and the microfiche systems were evaluated.

The Dual-Fiche concept charts a path that promises to be a cost-effective alternative to existing AIS instructional media and promises the additional benefit of routine update and revision of instructional modules that combine text and graphics.

SUMMARY

The feasibility of using microfiche as an alternative medium for the delivery of technical training has been investigated. The objective of this study was to develop microfiche formats for selected types of instructional materials, to produce the materials utilizing the formats developed, to conduct student trials of the microfiche in courses currently using the Advanced Instructional System (AIS), and to determine the optimal approach for continuing to build the microfiche capability within the AIS.

Background

The AIS media subsystem utilizes "alternative track" instructional modules that rely heavily on illustrations, either photographs or graphic renderings. These modules are presently delivered by audiovisual media, Illustrated Texts, and video systems. Where large learning centers are involved, these materials accumulate and create administrative burdens that could be addressed if the microfiche were adapted to the learning environment. The applications envisioned were: (1) the conversion of color intensive AV modules to microfiche; (2) the formatting of the microfiche to deliver both primary and alternative track modules in an integrated "multi-track" module, and (3) the use of microfiche in testing and test control as well as a primary instructional medium.

The microfiche medium offers proven advantages in the management, storage, and retrieval of information, and it has potential cost advantages. The study was directed toward developing microfiche formatting concepts and microfiche production methods to capture the power of the medium for delivery of both text and illustrations in an instructional environment.

Approach

The approach taken was to devise a microfiche system that met administrative and production criteria; classroom trials were conducted to determine if the system met student use criteria. The system is called the Dual-Fiche concept. The Dual-Fiche concept provides a way to separate the production of the text component of an instructional module from the production of the graphics component, and yet combine or merge the two types of information at the point of use--the microfiche reader. The purpose of this development was to bring the power of Computer Output Microfilm (COM) to bear directly on the problems of updating and revising instructional materials while gaining the flexibility necessary to produce graphics (particularly color-intensive graphics) consistent with content formatting requirements. The concept should be understood as involving two transparencies, one with text and the other with graphics. Images from each transparency are projected simultaneously, much as is done with complex viewgraphs having registered overlays that are projected together.

Prototype development confirmed the feasibility of the Dual-Fiche concept. Applications were then developed in which nine lessons on Basic Soldering Techniques were formatted for multi-track, color intensive presentation on microfiche. In addition, block tests were produced also using the COM production techniques. Classroom trials were conducted and the microfiche systems were evaluated. The nine lessons were prepared in two different versions in order to gain experience with different microfiche formatting techniques. The techniques were associated with different costs of production and they demonstrated basic principles that affect the way text and graphics can be integrated on microfiche.

Results and Conclusions

This study engaged the family of issues that surround the development of microfiche as an instructional medium. The development of the Dual-Fiche concept charts a path that promises to be a cost-effective alternative to audiovisual media and it promises the additional benefit of routine update and revision of instructional modules that combine text and graphics. No serious problems were encountered in the classroom trials and it appears that student acceptance of the medium is high. Further development of the concept is recommended but such development should take place in a training environment where significant administrative values accrue because of the need to update or revise instructional materials. Testing applications are obvious candidates. The optimal path is one in which further developments are routinely incorporated in a course of instruction, evaluated, and new developments incorporated in an iterative fashion.

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I. INTRODUCTION

Implementation of the Advanced Instructional System (AIS) called for the use of a broad range of instructional media, some traditional, some innovative, but all designed to complement individualized, self-paced, computer-managed training. The AIS is a prototype system merging computer technology and media development for the administration and management of individualized technical training on a large scale. It is within the framework of this system development that the feasibility of using microfiche as an alternative medium for the delivery of instruction has been investigated.

Interest in the potential of microform, specifically microfiche, as an instructional medium stems from two considerations: (1) the medium has proven advantages in the management, storage, and retrieval of information, and (2) the medium promises significant cost advantages when it is compared with other media. The problem addressed in this research was to determine when and how the proven and potential advantages of the microfiche could be realized in an instructional environment--the AIS environment as a practical case in point. The microfiche medium is an attractive option for a host of administrative reasons, but the feasibility of microfiche in instructional applications must finally be assessed in terms of its contribution to technical training objectives.

The objective of this study was to determine the feasibility of using innovative microfiche formats for selected types of instructional materials, to produce the materials utilizing the formats developed, to conduct student trials of the microfiche in an ongoing AIS environment, and to determine the optimal avenue for a continued microfiche capability within the AIS at Lowry AFB.

Background

AIS instructional modules (some 500 in number supporting four courses representing three Air Force career specialities) are classified as either primary or alternate track in nature. In most AIS courses, the primary track is a print medium. Alternate track modules are designed to meet the same lesson objectives as the primary track and can be delivered by audiovisual media, Illustrated Texts,* or alternate forms of print media. Alternate modules are further delineated by distinctions of "media overlap" or "multi-tracking." Media overlap constitutes adaptation to another instructional medium with only those changes necessary for the adaptation to the new medium in evidence. Multi-tracking implies a major restructuring of the content to meet a particular instructional strategy, difficulty level, or approach. These "multi-tracking" and "media overlap" modules were considered by the Air

*Illustrated Texts, pictured in Figure 1, make intensive use of illustrations in a book format; the intensive use of illustrations is characteristic of AIS alternative track modules.

Force Human Resources Laboratory (AFHRL) to be potential candidates for microfiche implementation, along with certain progression testing applications.

In planning for this study, AFHRL also considered the potential utility of Computer Output Microfiche (COM). This technology could link the computer-based lesson development capabilities inherent in the AIS with the direct production of course materials on microfiche. While the limited graphics capability of the COM impose constraints on its use for AIS instructional modules, student-testing applications were thought to be practical.

Further, it was thought that the microfiche might be a cost-effective substitute for prenarrated filmstrips if some way could be found to accommodate the problem of merging text and illustrations. An effective merger would be difficult because the microfiche technology has evolved with emphasis on data and documentation characteristics; hence, microfiche with the negative image polarity and high information density is found in the printed text elements. The film-based component of instructional media, on the other hand, has evolved with emphasis on the characteristics of the visual content; hence, filmstrips and slide presentations with color illustrations with low information density are together with printed text elements.

A research agenda formulated from these speculations was focused on specific AIS applications:

1. The use of microfiche formats in structuring multiple level (multi-track) instructional materials

2. The use of COM for the generation and control of tests and test items

3. The use of color microfiche as a substitute for traditional prenarrated sound-slide or filmstrip formats.

This agenda was used to guide the investigation reported here and to ensure that the feasibility of microfiche applications within the AIS framework was broadly examined.

Principal Phases in the Study

The study began with an assessment of the characteristics of AIS instructional materials and the AIS environment. Preliminary plans were developed for implementation of the microfiche products, including equipment acquisition. The Dual-Fiche concept for merging color illustrations and COM-generated text was formulated during this phase and the preliminary development of the concept was completed, including verification of the technical feasibility for fiche production. Section II of the report discusses this phase of the study.

The second phase of the study involved the development of materials for testing applications and for classroom trials. A performance-oriented block of instruction was selected for the classroom trials, and two versions of the instructional content were developed. This phase

included the development of fiche formatting concepts that engaged basic issues involved in the presentation of color-intensive illustrations and text (Section III).

Classroom implementation constituted the third phase of the study, and the results of these trials are considered to demonstrate the feasibility of COM-generated microfiche applications in both testing applications and as an integral part of the Dual-Fiche concept for the delivery of color intensive, multi-track instructional modules (Section IV).

Recommendations

As will be seen in the discussion presented in this report, each phase of work was disciplined by a concern with how technical training could be enhanced through further development of microfilm applications. These considerations were the driving force behind the formulation of the Dual-Fiche concept and the attention given to integration of production techniques into the capabilities of the AIS and the Air Force training systems more generally. Recommendations for further development are presented in Section V, along with information concerning the cost-effectiveness of microfiche applications.

II. DEVELOPMENT OF THE DUAL-FICHE CONCEPT

The initial effort made in this study was to conduct and document a feasibility survey within the existing AIS program to determine optional applications areas for microfiche implementation and to aid in the selection of viewing equipment. The four courses of instruction employing the AIS were analyzed in an effort to establish criteria for selecting particular application areas.*

The purpose of the survey can be clarified by examining Figure 2 where a flow chart showing the steps required to prepare and produce AIS materials is presented. The shaded area on the chart represents the scope, actions, and limitations of the overall study when compared to the technical and management requirements for introducing courseware on a large scale. This perspective is important because it demonstrates the context in which the results of the study must be evaluated.

Results of the Feasibility Survey

The survey effort resulted in the incorporation of administrative criteria, along with criteria related to the use of instructional modules. As a practical matter, it was apparent that the applications chosen should be limited to stable blocks of instruction, at least for the duration of the study. It was found that stability could be guaranteed only for a limited number of AIS modules. The transition of AIS from a research project to an operational system within the Air Training Command (ATC) was planned for January 1978, and curriculum revisions were generally anticipated in each of the AIS courses. To make matters somewhat easier, it was found that alternate track AIS modules were generally of the same length and of consistent format (e.g., Illustrated Texts from different blocks were similar), with no distinguishing characteristics that might influence the selection of application area except for content.

The initial impression that access to stable blocks of instruction might be more important as a selection criterion than the characteristics of the existing instructional modules was reinforced when the contents of particular modules were studied. These modules were analyzed at the suggestion of course personnel on the assumption that they represented stable blocks of instruction and that, if the microfiche "conversions" were successful, the converted materials might be used routinely after a period of classroom evaluation.

The analysis indicated that conversion of the modules could be approached on a rather straightforward basis if the module was considered to stand alone. For example: The Illustrated Script is a hard

*The four courses in which the AIS was implemented at Lowry AFB were Inventory Management (IM), Materiel Facilities (MF), Precision Measuring Equipment (PME), and Weapons Mechanic (WM). The WM course was redesignated Aircraft Armament Systems Technician in 1978.

AIS LESSON AUTHORING & PRODUCTION CYCLE

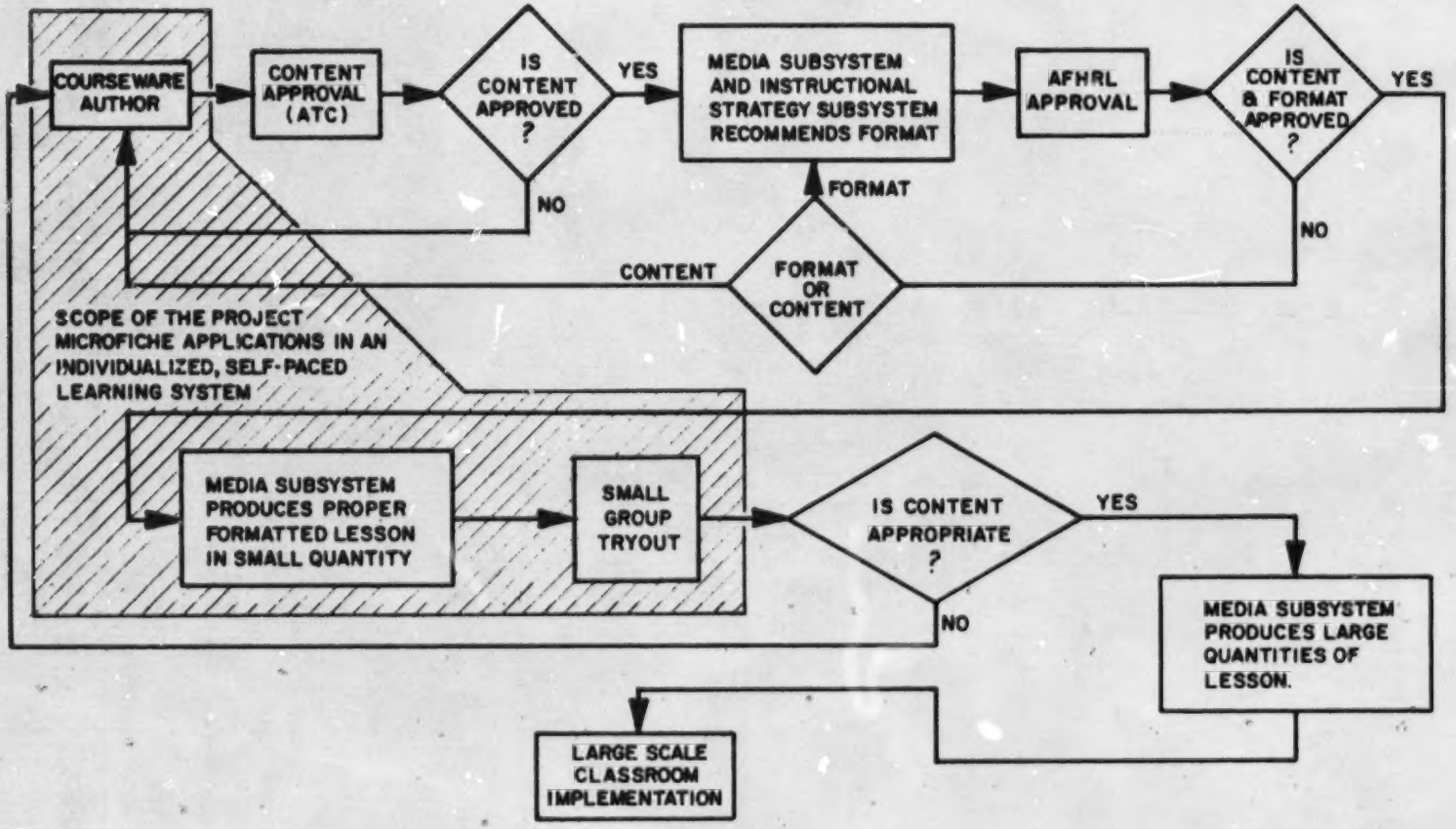


Figure 2*

*AIS Lesson Authoring and Production Cycle developed by McDonnell Douglas Austronautics Company - East for use in the Advance Instructional System.

copy version of the narrated filmstrip. Three illustrations from the filmstrip are formatted along the left-hand side of a page and the associated narration is printed to the right of each picture. A standard 98 image microfiche could be used to reproduce a similar format in color, perhaps organized by column rather than row in order to better capture the sequential nature of the instruction.

A similar approach could be taken with the Illustrated Texts. The standard 63 image COM microfiche could be used to reproduce the Illustrated Text in a two-pages-at-a-time format. Such approaches were considered to be trivial. Even though each approach could be refined, the problem that remains is how to integrate the microfiche modules into a block of instruction.

Further examination of these selected blocks of instruction demonstrated that different patterns in the implementation of the microfiche could be expected as a result of the different approaches taken in the design and selection of the AIS materials for particular blocks of instruction. For example, in Block 8, Lesson 8 (PME), the multitracking concept was implemented through the use of different combinations of the alternative track modules in conjunction with programmed texts (the primary track) and Technical Orders (TOs). Each combination (there were four possible) suggested a different microfiche formatting concept. Each of the other blocks had equally complex but different patterns in the way the lesson modules were implemented. In Block 6 (WM), the six AIS lessons employed either programmed texts or audiovisual (AV) modules as the primary track, each used in conjunction with an appropriate TO. The AV modules were reserved for performance-oriented training and this "use environment" clearly dictated the AV choice. The problem in terms of implementing the microfiche applications appeared to be one of finding a common denominator so that a single hardware system (with some variations) could be designed to enjoy wide applicability with AIS.

The common denominator emerged in a surprising way. A basic difficulty with instructional modules (and training materials more generally) is updating or modifying contents in response to changing environments, both internal and external to a training school. The need for basic improvement in the ability to incorporate changes was dramatized by the AIS transition, but the underlying need was manifest during the process of identifying stable candidate blocks and lessons for microfiche implementation. Thus, it became apparent that one of the criteria for pursuing the microfiche application should be ease of updating the contents of instructional modules. This realization led to the decision to employ computer output microfilm as the means for producing all text portions of AIS modules as well as for the production of test items (one of the specified application areas for this investigation).

This decision introduced a new challenge, that of finding a way to incorporate graphics, including color illustrations and flat art, with the COM-produced microfiche. This challenge stimulated the development of a concept for merging information recorded on separate microfiche.

The Dual-Fiche Concept

The Dual-Fiche concept envisioned a system of fiche production that would use a COM-produced positive microfiche to deliver the text portion of an instructional module and a color microfiche to deliver the graphic portion of the instruction. By placing the text and the graphics in reserved areas on each film, it appeared possible to merge the text and graphics using the projection system of the reader. Merging of the text and graphics appeared to involve only the careful registration of the two fiche while placing the respective films in emulsion-to-emulsion contact. It was thought that a custom-made, clear plastic envelope could provide the necessary registration while helping to keep the microfiche clean.

The concept had unique advantages when examined in light of the results obtained from the survey of application areas. For example, updating the text portion of the microfiche could be done without reprocessing any of the graphics. The COM fiche that has outdated information is simply disposed of and a new COM revision packaged with the fiche containing the graphics. In this way, the high unit cost component of the module, e.g., the color graphics, can be reused while the low unit cost component can be replaced as needed. Some of the other advantages include:

1. The basic concept could be adopted for producing multi-track modules, tests and test items, and AV conversions.

2. A single system integrating fiche production and microfiche viewing equipment was established. This advance made it possible to select microfiche readers for the implementation trials according to system specifications.

3. The power of the main-frame computer supporting the AIS could be brought to bear on the development and production of courseware. (This potential makes it practical to talk about updating courseware by directly linking the editorial and lesson development function, which resides in the technical school, with the means for producing courseware.)

With the concept in hand, attention was turned to developing COM production techniques and graphics capability. Prototypes of the Dual-Fiche were developed for a multi-track lesson, a block test that included simple diagrams and an AV conversion. The principal problems encountered and their solutions are discussed in the following paragraphs.

COM Production

The computer system at the University of Denver was used to develop prototype production techniques. While the system had limited "word processing" capability, software was developed so that edited text could be ordered and reordered as a part of the fiche formatting process. Documentation packages of the procedures and the requirements for producing a Printer Backup Tape suitable for producing the microfiche at a local COM service bureau were developed. As this phase was completed, AFHRL developed the software necessary for the production of Printer

Backup Tapes and installed additional editing routines in conjunction with the source program editor (SPE) used with the AIS computer (Control Data Corporation Cyber 73-16). These changes made it possible to shift the production of the microfiche developed for classroom implementation during Phase 2 from the University of Denver to the AIS computer system at Lowry AFB.

Color Microfiche Production

Various production options were evaluated in an attempt to discover the practical problems associated with color microfiche. A site visit to the Eastman Kodak Company laboratory at Rochester, New York, made it clear that the restrictions imposed by commercial production of color fiche would not give the desired flexibility in microfiche formats thought to be needed if, for example, multi-track formats were to be made. These restrictions were seen as defining the format for the Dual-Fiche, and this was not satisfactory given the applications under investigation.

Perhaps a larger problem was that the capability to produce the color microfiche would rest primarily with a second party not directly involved with the development of the content of the microfiche modules. This was seen as being inconsistent with bringing the text portion of the instructional content under control of the content specialists in the training schools. As a result, techniques were developed (they are reviewed in the next section) which would allow an Air Force production agency to produce color microfiche masters that could be duplicated by local photographic laboratories.

Fiche Formatting Concepts

The fiche formats prototyped during the preliminary evaluation of the Dual-Fiche concept are summarized below. Four lessons were designed with the objective of coordinating between content and production constraints. One design factor that was common to each format was the desirability of vertical formatting rather than using horizontal formats. This factor reflects the sequential nature or flow in the lesson content, and it can be best preserved by the vertical formatting of information. Table 1 tabulates the factors that were accommodated in the design of the prototype fiche.

Block 6 Lesson 1 (WM)

Type: Programmed text with graphics

Style: Vertical and horizontal progression

Format: Text and graphics on same frame. Embedded questions on corresponding frame, next column. Restatement of question and answer on right of frame, located on line corresponding to correct multiple choice answer. Self-test in

last column with restatement of question and answer to right of and on same line as correct multiple choice answer.

Block 6 Lesson 2 (WM)

Type: Filmstrip/tape

Style: Vertical progression

Format: Text and visuals on same frame. Use of oversized visuals on selected frames. Embedded questions appear on separate frame throughout lesson. Answers to embedded questions located at bottom of each frame. Self-test on last column with restatement of question and answer to right of and on same line as correct multiple choice answer.

Block 6 Lesson 5 (WM)

Type: Programmed text

Style: Vertical progression

TABLE 1
A TABULATION OF LESSON CONTENT FACTORS ACCOMMODATED BY FORMATTING

Type	Example	Text	Graphics	Questions	Answers	Self Test
Programmed text with graphics	Block 6 Lesson 1	√ Appear	√ on same frame	√ Separate column	Right side of frame	√ Last column
Filmstrip/ tape	Block 6 Lesson 2	√ Appear	√ on same frame	√ Same column, separate frame	√ Bottom of frame	√ Last column
Programmed text--no graphics	Block 6 Lesson 5	√		√ Separate Column		√ Last column
Test	Block		√ Appear	√ on same frame		

√ Indicates that this element appeared in the prototype microfiche.

Format: Test in odd numbered columns. Questions in even numbered columns. Information density varies. No graphics (some visuals suggested).

Test

Type: Block test

Style: Vertical progression

Format: Questions, multiple choice answers, and diagrams appear on same frame. Information density usually low.

Equipment Selection

As indicated earlier, the decision to make COM-produced microfiche the building block for the microfiche applications gave specific directions to the equipment selection process. Three models of microfiche readers were purchased, based on mechanical, optical, and maintainability criteria, and they are pictured in later sections of this report.* The system was based on 24X fiche reduction to conform with one of the standard fiche reduction ratios available on COM equipment. The 24X ratio also coincides with the maximum practical reduction that can be used in making satisfactory color microfiche. The three models made it possible to match the aspect ratio of the COM-produced image with the aspect ratio of the reader screen. The largest screen size, 11 by 14 inches, would display a normal page of computer printout in actual size. This "horizontal" aspect ratio was considered to be ideal for combining text and illustrations, particularly in a side-by-side format.

*Additional equipment, including reader-printers and portable microfiche units were also purchased in order to have flexibility in implementing specific applications.

III. DEVELOPMENT OF COURSE MATERIALS

The Second Phase of the study began with the decision to implement the color microfiche in Block 14 of the Weapons Mechanic course. This block of instruction promised to be a challenge because it was highly performance oriented. It was concerned with the basic techniques for soldering electronic components, and with the students using solvents, flux, solder, heat, files, brushes, and so on, it was clear that microfiche application was a difficult one.

The primary track modules used in this block were a group of four Illustrated Texts covering nine instructional objectives. The choice of the block was the result of a series of administrative considerations that were related to (a) the AIS transition process, (b) the need for stability in content, (c) the advantage offered the project team of becoming familiar with only one technical subject, and (d) the opportunity to develop the multi-track application in conjunction with a color-intensive application.

The multi-track application in which the instructional content available in the primary track is restructured to give the student an optional or second path to achieve instructional objectives was found to be represented in the materials included in the TOs used in the Block. The TO is a manual entitled General Shop Practice Requirements for the Repair, Maintenance, and Test of Electronic Equipment. Materials would be taken from the TO and integrated with the corresponding subject matter presented in the primary track to achieve a complementary, but not independent, path to reach the instructional objectives.

The fact that the color conversion was based on a set of Illustrated Texts rather than AV presentations was not considered significant. The content for Illustrated Texts and AV modules are, to a significant extent, interchangeable. That is, the audio portion of a lesson is typically presented as text in the Illustrated Text, while the visual portion is captured on 2 by 3 inch (50.8x76.2mm) color prints. The "negatives" used to produce a filmstrip can also be used to produce an Illustrated Text. The decision to use the Illustrated Texts from Block 14 was thought to be of little consequence in terms of the overall study objectives, since the comparative cost picture would be developed from the AIS experience with AV modules.

Two Versions of the Dual-Fiche

Figure 3 presents examples of the different versions of the microfiche implemented in Block 14. The two versions represent different approaches to the problem of integrating text and graphics within an individual frame or reader display field. The formats of the fiche are the same, except for the approach taken when specific student performance is to be guided. (Compare the layout patterns for Columns 4, 5, and 7.)

It should be noted that the microfiche developed for Block 14 implementation are not the standard 4 by 6 inch (105x148.5mm) size. The standard COM fiche would have nine columns instead of the seven shown in the figure. The last two columns of the standard fiche were not used in this phase only because it was expedient not to use them. The color film that serves as one component of the Dual-Fiche concept is available in precut form and in small quantities only in 4 by 5 inch (105 by 127mm) or 5 by 7 inch (127 by 177.8mm) sheets. Since this phase of the research was highly developmental, it was attractive to work with smaller units of information on each fiche, as well as to minimize the cost of film and film processing. The small-size fiche was made by simply trimming off the unused columns.

Version I is called Progressive Sequence, because the images and text are combined in the performance columns so that the previous step pictured and explained is always on the reader screen when the next step is shown. The familiar "frame" is not the building block in the Progressive Sequence Version--rather it is the column. Version II is called Full Frame because, and as the figures show, the frame is the basic building block for the information presented in the performance columns.

The formats of the two versions are the same in many significant respects. In the example shown, Lessons 1 and 2 are formatted in seven columns with identical text in each column. The number of illustrations is the same, the TO content is the same, and the structure of each lesson, as represented by the information in each column, is the same. In fact, the first row of the fiche--called a visual index to the content in each column--has identical information, only the way the text and visuals are related on the screen is different, and this difference becomes significant in the performance columns 4, 5, and 7. Figure 4 shows these differences by a side-to-side comparison of what a student might see on the screen.

While the difference in visual impact due to color cannot be demonstrated because the comparison is in black and white, the amount of visual information differs greatly, and the relationship between the text and illustrations is also different. The significance of the two versions should be understood from two perspectives; one relates to cost of production, the other perspective relates to the integration of text and visuals using microfiche. An overview of production-related considerations will be presented first.

The Production Cycle

Figure 5 shows the major steps in producing Dual-Fiche in both versions. Step 1 is the familiar lesson authoring and planning activity associated with the development of any instructional module. At this state, the Block 14 lessons were designed according to format rules, such as the organization of lesson elements by column and the use of the visual index in Row 1. The fiche shown in Figure 3 are organized so that general TO information is included in column 1, and tools and equipment for all lessons are shown in column 2, plus specific TO information related to equipment items. Column 3 introduces the first lesson with a picture of an unformed soldering tip. A list of equipment items

PRODUCTION CYCLE FOR THE EXPERIMENTAL DUAL MICROFICHE

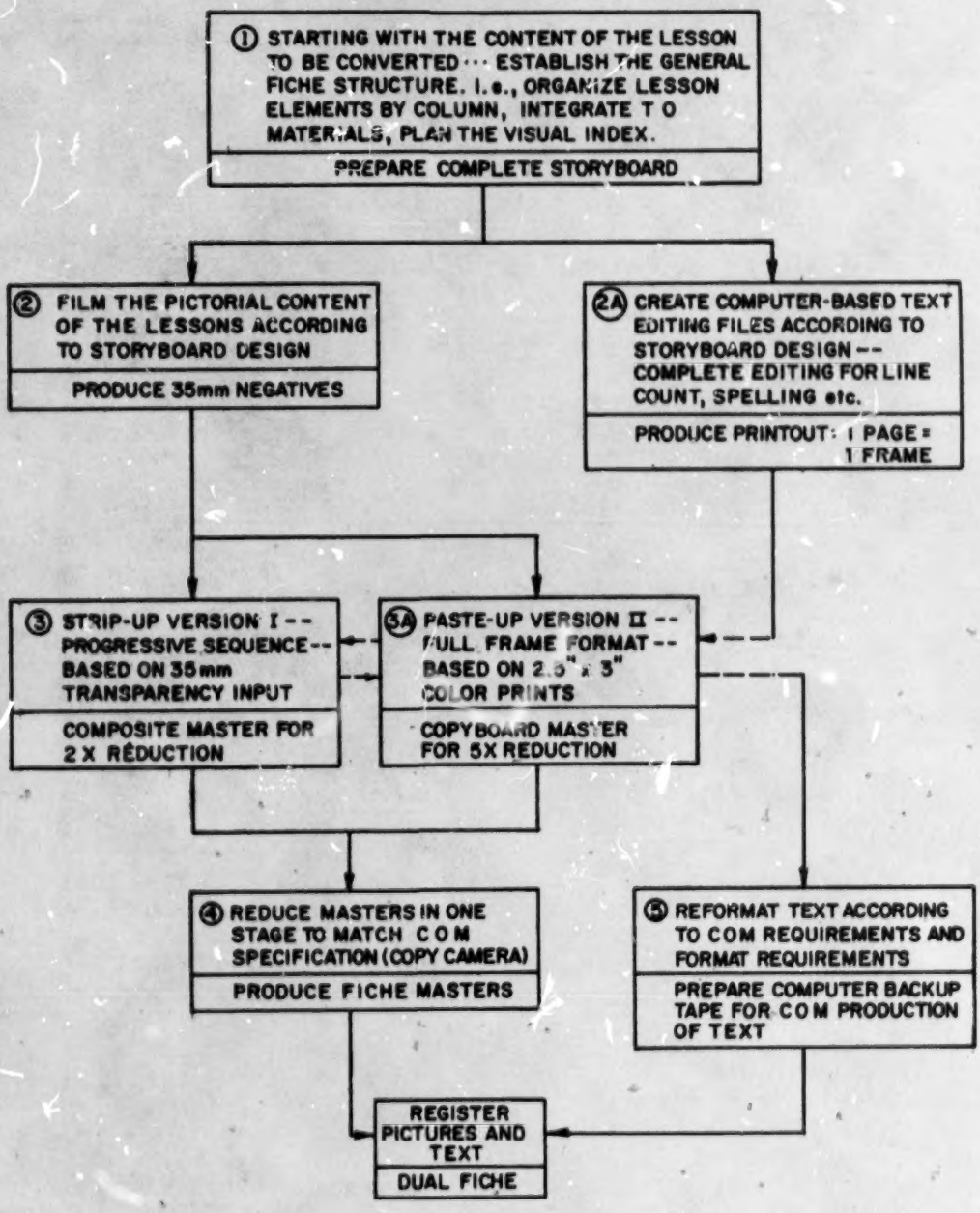

① STARTING WITH THE CONTENT OF THE LESSON TO BE CONVERTED ··· ESTABLISH THE GENERAL FICHE STRUCTURE. I.e., ORGANIZE LESSON ELEMENTS BY COLUMN, INTEGRATE TO MATERIALS, PLAN THE VISUAL INDEX.
PREPARE COMPLETE STORYBOARD
② FILM THE PICTORIAL CONTENT OF THE LESSONS ACCORDING TO STORYBOARD DESIGN
PRODUCE 35mm NEGATIVES
2A CREATE COMPUTER-BASED TEXT EDITING FILES ACCORDING TO STORYBOARD DESIGN -- COMPLETE EDITING FOR LINE COUNT, SPELLING etc.
PRODUCE PRINTOUT: 1 PAGE = 1 FRAME
③ STRIP-UP VERSION I -- PROGRESSIVE SEQUENCE -- BASED ON 35mm TRANSPARENCY INPUT
COMPOSITE MASTER FOR 2X REDUCTION
3A PASTE-UP VERSION II -- FULL FRAME FORMAT -- BASED ON 2.5" x 3" COLOR PRINTS
COPYBOARD MASTER FOR 5X REDUCTION
④ REDUCE MASTERS IN ONE STAGE TO MATCH COM SPECIFICATION (COPY CAMERA)
PRODUCE FICHE MASTERS
⑤ REFORMAT TEXT ACCORDING TO COM REQUIREMENTS AND FORMAT REQUIREMENTS
PREPARE COMPUTER BACKUP TAPE FOR COM PRODUCTION OF TEXT
REGISTER PICTURES AND TEXT
DUAL FICHE

Figure 5

needed and specific TO information related to making a tip for a soldering iron follow in the same column. Column 4 starts with a picture of the completed tip and continues with detailed information on how to achieve those results (the performance column). The next objective, making a tinned soldering tip, is pictured in column 4, and the steps necessary to tin a soldering tip are presented in the remainder of the column. This pattern of columns devoted to introduction, TO information related to performance, and then performance, was repeated throughout the four fiche and nine lessons required in the block.

These formatting rules were captured on a detailed "story-board," which was used to direct the photographic work needed for the illustrations (step 2) and to input the text related to these illustrations into a computer file (2A). The editing file for each fiche was set up so that text could be placed in "file modules" that corresponded to each frame on a 24X microfiche, i.e., a 63 frame matrix of nine columns and seven rows. It should be emphasized that the content of the lessons, including text, pictures, and line drawings, was taken from the Illustrated Texts and the TO, respectively. Both the development of the story-board and the filming done to obtain new negatives for the color fiche conversion were closely coordinated with school personnel.

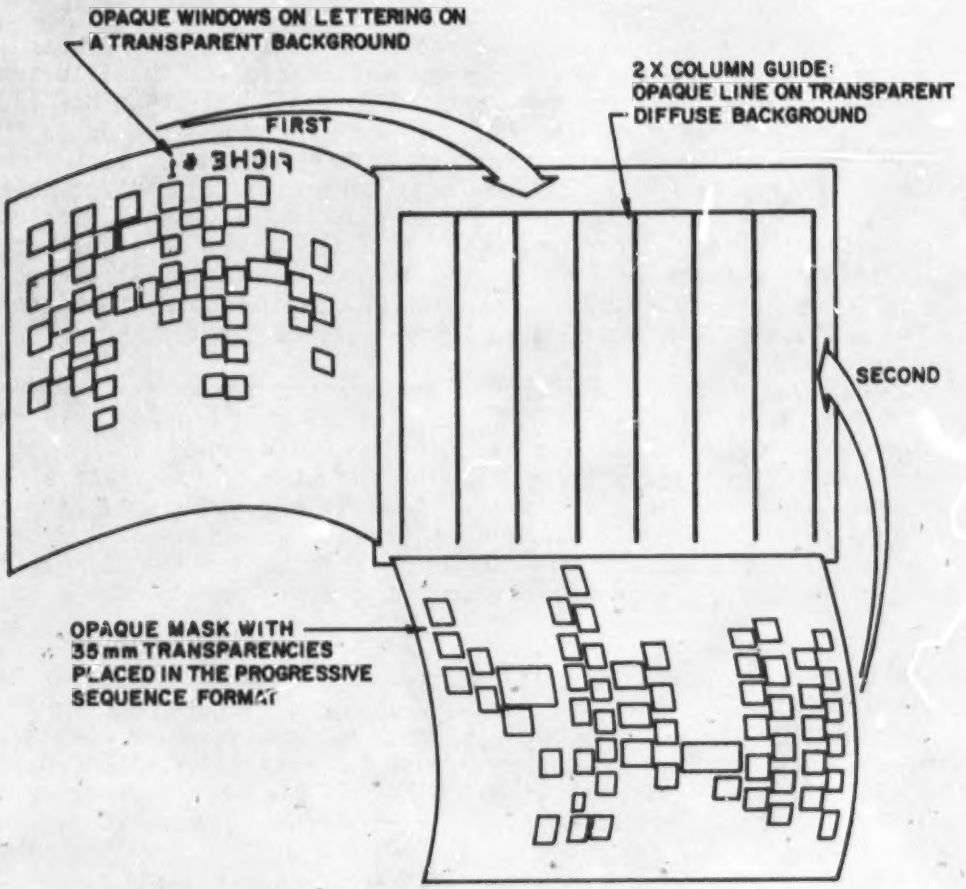
The next step in the cycle was to prepare the two master versions of the lessons, and Figures 6 and 7 show the basic differences in the production techniques used. One significant difference in the two versions, from a cost perspective, is that Version I, Progressive Sequence uses 35mm transparencies as the input for stripping up a composite master, while the Full Frame version uses color prints (2 1/2 by 3 inch) to assemble the master. The major cost factor is that of making the prints for the Full Frame version; otherwise the costs are comparable.

Technically, it would be possible to photograph all illustrations using slide film and obtain the necessary input for Version I. In this way, one generation in photographic reproduction is eliminated, but at a price because the original photographs must be carefully controlled for uniform exposure from image to image. This is the principal value of producing an original negative, i.e., the exposure can be controlled for, either in printing the 2 1/2 by 3 inch (62.6 by 76.2mm) positives or in printing transparencies having different densities, and selecting among the prints for the best exposure.

Step 4 was straightforward. The composite masters were reduced to make distribution copies of the color fiche directly. A fiche master could have been made if a large number of copies were required. The significant thing about step 5 is that the film system used was EKTACHROME professional film (Tungsten 50) developed with E-6 processing.* The film has a resolution of more than 100 lines/mm when carefully processed; and when used in conjunction with a high quality, color-

*E-6 processing of large transparencies is routinely done by local laboratories on a custom basis. The requirements for producing and processing large numbers of duplicates would require custom equipment if undertaken by a local laboratory or an Air Force production agency.

COMPONENTS FOR THE STRIPUP OF VERSION I - PROGRESSIVE SEQUENCE


OPAQUE WINDOWS ON LETTERING ON A TRANSPARENT BACKGROUND
2 X COLUMN GUIDE: OPAQUE LINE ON TRANSPARENT DIFFUSE BACKGROUND
FIRST
FICHE #1
SECOND
OPAQUE MASK WITH 35 mm TRANSPARENCIES PLACED IN THE PROGRESSIVE SEQUENCE FORMAT

TWO EXPOSURES NEEDED TO CREATE MASTER FICHE
FIRST EXPOSURE CLEARS THE FICHE BACKGROUND WHILE LEAVING THE IMAGE AREAS UNEXPOSED.
SECOND EXPOSURE PRINTS THE 35mm TRANSPARENCIES IN THE PREVIOUSLY UNEXPOSED AREAS.

Figure 6

COPYBOARD COMPONENTS FOR VERSION II - FULL FRAME

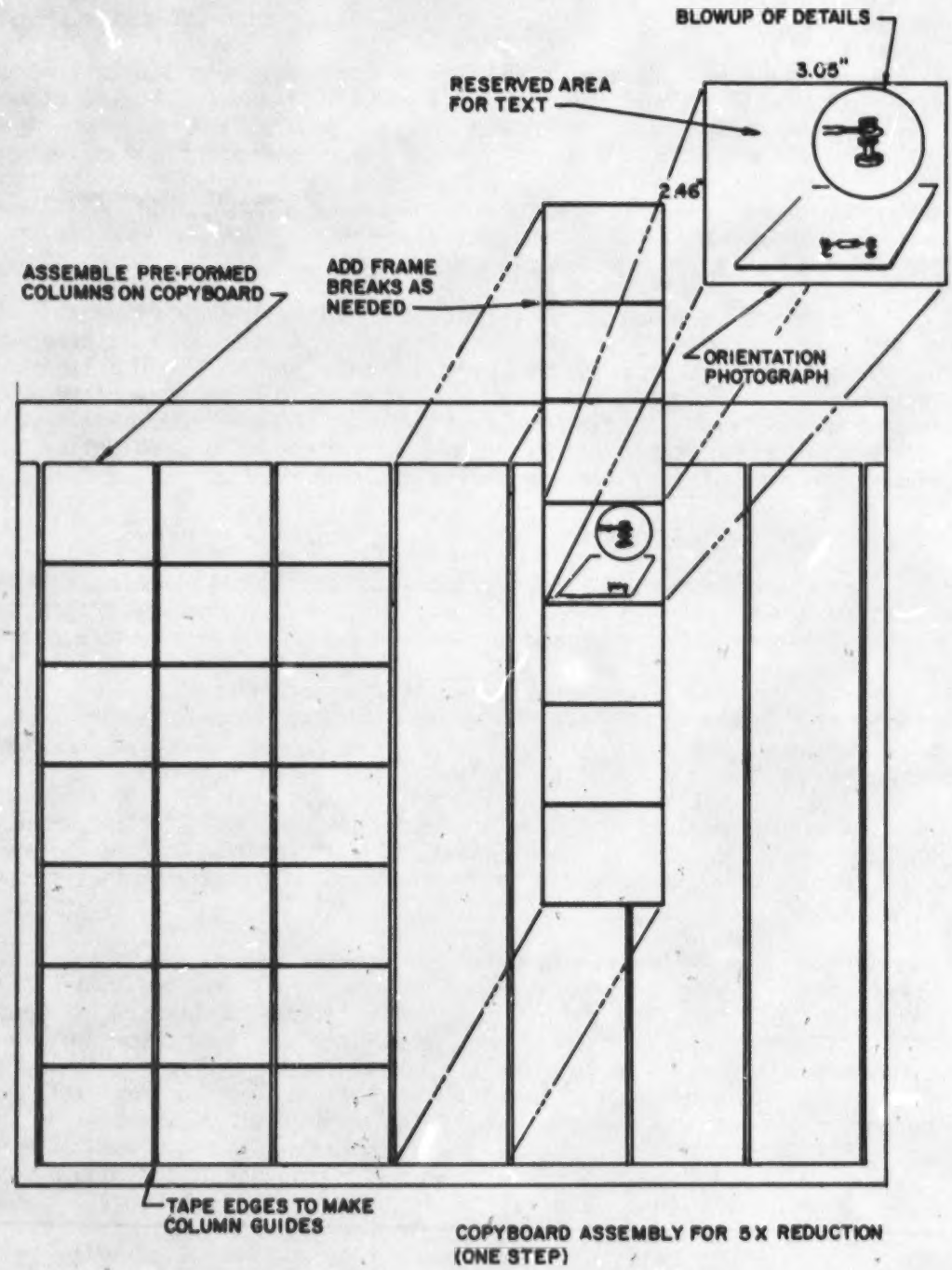


Figure 7

corrected lens, it produces excellent image quality if the image reduction attempted does not exceed a factor of five.

The reformatting of the text (step 5) was accomplished by positioning the text fields within each computer file module (a file module = one frame on the COM fiche) so that the fields corresponded with the placement of the illustrations on each composite master. Typically, this meant using the editing capability in the computer's Source Program Editor to move blocks of text from one side of the frame to the other, to move text from frame to frame, and to generally tailor the text component so that it was visually related to the appropriate illustrations. When the text reformatting was completed and verified by comparing the computer printout with each composite master, a magnetic tape (printer backup tape) was made, and a microfiche master was produced from the tape by a local COM service bureau.

In order to complete the sets of Dual-Fiche needed for classroom trials, positive copies of the COM microfiche master were attached to the color transparencies by double-sided adhesive tape. The tape was placed at the top edge of the fiche so that it did not interfere with emulsion-to-emulsion contact between the two fiche in the body of the information area. After attaching the top fiche, the combination was trimmed and sets of four were assembled as shown in Figure 8.

Integration of Text and Visuals

The development of the two versions of the Block 14 materials was driven by the fact that there are many different ways to approach the problem of integrating text and visuals on microfiche, and there are no criteria presently available that would help guide this work. In examining the problem closely, however, there appeared to be two basic approaches. Either the text is a part of the frame, overlaid in a "quiet" portion of the illustration (as was done in the Full Frame approach) or the illustration is displayed as a "frame" within the larger display area and the text placed in close proximity so that both are displayed together. The problem arises because the familiar printed page is not being used as the input to the microfiche, as is the case when, for example, a document is filmed with a step-and-repeat microfiche camera.

At the risk of overstatement, the problem arose here because the microfiche is being developed as an instructional medium, capable of delivering both text and color visuals; it is not being used as a substitute for hardcopy documentation. When each of the basic approaches was examined in light of the way a student might be expected to use or process the information contents of the lessons, it was realized that the way the text and visuals were integrated might support or hinder use. This possibility arises from the fact that only one frame or image area can be displayed when the microfiche is projected. The frame-by-frame presentation that results can impose an artificial hierarchy on the information presented; that is, main ideas and subordinate ideas in the lesson content tend to be treated at the same level. And the level is dictated only by the "space" or screen area needed to present the information. The problem may be best seen when there is a relationship between two or more ideas, as is the case in the lessons of Block 14.

The actions (or ideas) called for in the performance columns oftentimes were related. When this occurs, it is desirable to show the relationship between these actions.

In Version I, Progressive Sequence, this relationship was established by ensuring that two illustrations and their associated text were always on the screen. In the Full Frame version, a similar effect was achieved by combining illustrations--one showing the overall idea or gestalt and the other illustration "inset" in the same frame along with relevant text. The subordinate illustration often supplied additional details, and this made it practical to reproduce the detail at maximum size, consistent with the inset area restrictions.

The one feature of the fiche format that made these approaches feasible was to organize the lesson elements by column. The column provided the logical groupings for different types of content, and in those columns where the integration of text and visuals was important, i.e., the performance columns, the format provided the structure necessary to relate the performance information to the total lesson.

The utility of these concepts has not been directly investigated nor have criteria been adequately developed to distinguish between their respective utilities. The classroom implementation reported in the next section shows that students could react to the different versions and attempt to state the reasons for their preference. This question should be explored, however, if the microfilm is to reach its potential as an alternative instruction medium.

Block Test Development

The development of procedures for the production of block tests using COM was an important part of the overall effort. The main purpose of this development was to gain experience with the use of microfiche readers and COM-produced microfiche in the delivery of block tests. Since the AIS computer is already used routinely to help develop the content for block tests and to provide test scoring keys, it was essential to determine if computer-produced microfiche might also be an effective way to deliver the tests. If so, then the development and production functions for the tests could be merged. The development of the Dual-Fiche concept ensured that graphics could be merged with the COM-produced text component using black and white or color film as appropriate.

Four block tests were prepared using the COM production techniques described in Appendix A, and one test, Block 7 Weapons Mechanic, was evaluated in the school's Testing Center. Figure 8 shows the fiche packaging used to support this trial. Additional trials of other block tests were not attempted because test revisions had occurred in the interval between test preparation and implementation (3 months). The results of this trial are reported in the next section.

IV. CLASSROOM EXPERIENCE WITH EXPERIMENTAL MICROFORMS

Two classroom trials were conducted in which the experimental microforms were routinely used by trainees in the Aircraft Armament Systems School located at Lowry AFB. The trial using the COM-produced block tests took place over a 3-week period in October 1978 and the trial in which the Dual-Fiche were used in Block 14, Basic Soldering Techniques, took place over a 6-week period during September and October 1978. The results obtained from these trials are described in this section.

Block Tests

The testing facility in the Aircraft Armament Systems School was equipped with four Micro Design MINI COM microfiche readers, each having 24X magnification and gray screens. Figure 9 shows the arrangement of the equipment at one of the testing stations. During the trial period, 102 students took the Block 7 test, and 40 of these students used the COM microfiche-based test format on an ad hoc basis, as a function of station availability and the supervisor's workload at the time a student requested a Block 7 test.

A student, when assigned the microfiche test format, was shown how to load microfiche into the reader and how to use the reader controls while at the supervisor's station. After this orientation, the student was given a microfiche (either positive or negative image polarity), a copy of the evaluation questionnaire, and a copy of the instructions for taking block tests (the latter required by regulation). The student was then directed to one of the test stations, and no further assistance was given.

Block 7 tests are available in two versions, each with 20 questions. A particular version of the test was preassigned to the student based on AIS parameters. The questions in each version were composed of one- or two-sentence interrogatories and a list of four possible answers (multiple-choice). The questions and answers were organized in columns, one column for each test version. Further, each question was formatted on the fiche so that only one question-and-answer array could be displayed at a time. When the trial was begun, it was determined that one version of the test should be obscured from the student's view because a student who failed the test would be given the second version after remediation. It was thought that having only one version of the fiche would avoid potential compromise and perhaps confusion in the administration of the block tests. The necessary modifications to the microfiche were made simply by covering the appropriate column on the microfiche with an opaque strip of tape and doubling the number of fiche available for use in testing.

Student responses were recorded on the Generalized AIS Test Forms routinely used in all block testing. A student, after completing this block test, filled out the microfiche evaluation questionnaire, had the test form scored by machine (a feature of the AIS), and received a copy of the test results, including a prescription for further training

(advancement or remediation). At this point all test-related materials were returned to the supervisor. All student actions, with the exception of completing the questionnaire and the use of microfiche display instead of a test booklet, were routine--a routine established by student completion of earlier block tests.

Results

The principal purpose for conducting the block test trial was to gain experience with the factors that influence an effective microfiche-based test delivery system. These factors were assumed to include equivalent student performances, student acceptance (values), and administrative concerns. The only hypothesis under test during this trial was that there would be no difference in student scores on Block 7 tests as a function of test delivery medium--either the familiar booklet or new microfiche. Table 2 shows the statistical summary related to this hypothesis. The "t" test performed, based on the separate estimate of variance observed, indicates that there was no statistically significant difference in student scores.

TABLE 2. SUMMARY OF TEST SCORE COMPARISONS, BLOCK 7 TESTS

Instructional Mode	Student Sample Size	Mean Scores	Standard Deviation	Separate Variance Estimate T-Value	DF	One-Tail Prob.*
Microfiche	40	85.75	13.85	-.64	61	0.262
Booklet	62	87.34	9.13			

*A one-tail test was made because there was no reason to expect higher test scores on the microfiche system.

The microfiche evaluation questionnaire (see Appendix A) completed by students using the microfiche system provided the basis for gauging student acceptance. The principal results and comments by students are summarized as follows:

- Most students (95 percent) had no problems using the microfiche viewer. Two students had problems related to focus uniformity and eye strain.
- No student encountered problems with dust or fingerprints on the fiche (25 used the negative polarity, 15 used the positive polarity microfiche).
- Most students (97 percent) focused the display format--one question-at-a-time--satisfactory. Eighteen students commented on the preference for the format, i.e., it helps avoid errors; improves concentration; don't lose your place; helps in re-

viewing questions. One student responded that the format hinders your question review process.

- Suggestions for improving the system noted by individual students included the addition of a "centering control;" the insertion of a "last question marker;" the use of "plastic covers" to protect the fiche; pushing the platen "in," rather than "pulling it out," to advance from question to question; the use of a reserved "border" or "area" on the fiche to avoid fingerprints on the instructional content.

- Comments on the system included: it was easy to use (N = 3); the system is better than test booklets (N = 11); it is a "good system" (N = 9).

- The advantages noted included: no student markings on the fiche (N = 1); don't have to turn pages (N = 1); less space (N = 1); greater clarity (N = 4). The disadvantages noted were: lack of familiarity with system (N = 1), and the desirability of viewing more than one question at a time (N = 1).

- Four students made no comments beyond the yes--no responses called for in the questionnaire.

It was clear from an inspection of the questionnaires that student acceptance of the microform-based block test system is high. This conclusion was also strongly supported by supervisor feedback reporting student attitudes and by the supervisors' insights into how the system could be implemented more broadly.

Supervisor acceptance of the system can be traced to practical problems in testing and test administration more generally. Ensuring that there are no marks on a test booklet is an example of practical problems that may be solved by the microfiche system. The potential for routinely updating and/or reconfiguring block tests on a regular basis was seen as a need addressed by the microfiche system. The potential for using the microfiche to deliver an individualized test from a pool-of-test-items was suggested as a direction for further system development (i.e., to aid in retesting, as well as increasing the integrity of the testing process by avoiding test compromise). One target-of-opportunity identified for the system was the delivery of the mid-term and final examinations by microfiche. Updating test items and simplifying retest procedures (i.e., selective retesting on specific instructional objectives) were thought to be important applications.

Conclusions

The block test trial indicates that the COM-produced microfiche have a place in the delivery and administration of block testing. It should be noted, however, that further evaluation is needed before the practical limitations of the system (if any) are completely understood. For example, the Block 7 test is relatively short. Additional experience is needed with other tests that (a) are longer; (b) are more complex in subject and visual content; and (c) require the student to use

schematics, diagrams, TOs and manuals in conjunction with the microfiche display. Based on experience to date, however, there is no reason to suspect that a thoughtfully designed system would not enjoy student acceptance and meet the administrative needs found in computer-based instructional testing applications.

Performance-Oriented Instructional Trials

The classroom used to teach Basic Soldering Techniques, Block 14, was equipped with four Micro Design 4000 Series Readers, two each of the 4010 and 4020 models. The different models of readers were chosen to gain experience about image size requirements: Model 4010 displayed images at three-quarter normal size, while the Model 4020 displayed images, particularly the text portion, at actual size. Since the work stations normally used for this training are designed for two students to work at a station, additional readers were not deployed in the classrooms. As a result, students were assigned to the microfiche units as the units were available; otherwise students used the four volumes of Illustrated Texts for their instruction. This approach allowed the highly variable student flow in Block 14 to be accommodated without causing scheduling or workspace assignment problems for the instructors. Figure 4-2 shows the configuration of a work station with the reader in use by a trainee. During the trial period, 217 students completed Block 14, and 43 of these students completed the lessons using the microfiche system.

One apparent disadvantage of this approach was that the trial period was lengthy, approximately 6 weeks. The length of the trial period actually worked to improve the information produced, however. For example, four different instructors were assigned to Block 14 during the trial. This rotation caused three different instructor teams to become familiar with the microfiche system and its characteristics. Further, the rotation helped to minimize any instructor bias towards the microfiche system and helped to ensure that the trial was conducted within the constraints imposed by routine administrative requirements.

A student assigned to the microfiche-based instructional system, was given a film holder containing the four fiche, and the procedures for loading and unloading the fiche. The use of the reader controls was demonstrated for each student at the work station. Upon completion of the lessons in Block 14, the student was asked to complete an evaluation questionnaire as part of the documentation normally required for course continuation.

Since the microfiche-based instructional materials were assumed to be self-explanatory--as is the case with the Illustrated Texts normally used--the instructor-student interactions centered around the critiques of student progress in preparing the nine mechanical and electrical components explained in the instructional materials. The fact that the microfiche versions of the lessons routinely provided the guidance needed without involving the instructors in further explanations regarding the use of the microfiche, the location of instructional content within a particular microfiche, or new patterns of instruction because the microfiche systems were in use, is both evidence of the effectiveness of the system and a comment on the environment in which the trial

took place. Stated another way, if the microfiche system of instruction was found to require instructor intervention during student use, the trial would have terminated prematurely.

Results

As in the Block Test trial, the principal purpose of the classroom trial was to gain experience with the Dual-Fiche concept for the delivery of color-intensive, performance-related instruction. Because of the broad range of new concepts involved, the emphasis in this trial was given to establishing a baseline related to student performance and student acceptance. Student performance was gauged along two different dimensions, (a) the time to complete the block, and (b) observation of the patterns in student use of the microform materials. Table 3 shows the statistical summary regarding block completion times. The F test of sample variances showed that the hypothesis H_0: $\sigma_2^1 = \sigma_2^2$ could be accepted at the 80 percent confidence level.

TABLE 3. SUMMARY OF BLOCK 14 COMPLETION TIMES*

Instructional Mode	Student Sample Size	Mean Times (Minutes)	Standard Deviation	Pooled Variance Estimate T-Value	DF	Two-Tail Prob.
Microfiche	35	806.97	410.95	2.03	187	0.043
Illus. Texts	154	665.96	360.77			

*The sample size (189) does not correspond to the 217 students that completed Block 14 due to missing data and the imposition of data reliability constraints.

As may be seen by inspecting Table 3, the T test performed indicates that the differences between completion times is significant at 95 percent confidence level. Further, there was no evidence to suggest that the student populations from which the samples were taken was different: the ratios of sample variances for the student groups produce a value for $F_{38,154} = 1.30$, and none of the AIS Placement Test score comparisons suggest population differences, even at the 20 percent level of significance. One reason for the observed difference in completion is thought to be due to the inclusion of information from the TOs as a regular part of each lesson. Classroom observations indicated that students using the regular Illustrated Texts seldom referred to referenced TO information once the pattern of instructor approvals for student work was established in the routine of each trainee. Other reasons for the difference in completion time are related to the students' lack of familiarity with the microfiche reader and the fiche

formats, the fact that the student had to discover efficient patterns for using the fiche presentation, and the absence of time constraints characteristic of self-paced instruction.

Other factors contributed to the large variation in completion times observed. First, each instructor has his own set of norms for gauging the adequacy of the students' work. Differences in the norms resulted in very different "standards of acceptable student performance" being applied during student critiques. These differences were observed to double the student time required for completion of Block 14 objectives. Second, as the student load increased, the time for completion of an objective also increased due to the student queues that formed awaiting the instructor's approval of the students' work. Neither of the factors, however, is thought to have affected the students using the microfiche in some preferential fashion.

Student acceptance of the system was also gauged by questionnaires. Two versions of the same questionnaire were used (see Appendix A) because only the Progressive Sequence microfiche format was used during the first 3 weeks of the trial and the Full Frame format was not introduced until the last 3 weeks of the trial. During the latter period, students used both formats while completing the block of instruction. The two formats and concepts involved in their development have been described in the previous section. The principal results and student comments are summarized below:

- Most of the students (86 percent) found that the lesson organization on the microfiche was clear after they had completed the first two lessons (Fiche #1). Five students were not completely sure of the lesson format at this state of use, and one student was confused.

- Four students had problems using the reader or changing the fiche (window glare, upside-down fiche, poor focus). Most students (90 percent) stated that they had no problems and 15 of these students commented on the ease of use.

- Even though the classroom was a "severe environment" for the use of film and precision reader equipment (because of the soldering operations undertaken in conjunction with microfiche use), most students (84 percent) felt that dirt and dust on the microfiche were not a problem. Five students commented on the presence of foreign material, but felt that it "didn't make any difference." Two students were annoyed by its presence. These results were surprising, considering that the positive polarity of the microfiche made any foreign matter highly visible and the fact that each set of microfiche was used by an average of five students.

- The value of including the TO information as a part of each lesson was also recognized by most students (81 percent). Three students indicated that it was not helpful, and five students found it helpful only to a degree. Observations of student use patterns indicated that the TO information was carefully reviewed during the first three to five lessons.

After it became clear that instructor approvals of student work did not depend directly on TO information, students began to skip over TO material.

- There were many comments on the adequacy of the type-size used in the test portion of the materials. Sixteen students (37 percent) felt that the size was too small--eight students suggested that it should be larger, but that it was not critical--19 students (44 percent) felt that the type-size was no problem. It did not appear to matter which reader was being used, the 3/4 size or the full size. Approximately one-half of the students in both groups commented on the type-size, i.e., it could or should be larger.

- These results are consistent with the fact that the microfiche reader was often used beyond the normal reading distance of 14 to 16 inches, because of the performance-related tasks that were accomplished while the reader display was viewed. As an additional comment on the text size, the instructors reported that the students preferred to use the high-magnification projection lenses available on both models of the microfiche reader. These lenses displayed the fiche content at approximately 20 percent oversize. No data were gathered on the visual acuity of students--contact lenses, glasses, etc.

- Students that attempted to specify advantages and disadvantages of the microfiche system when compared with their experience with the Illustrated Text tended to compare the two modes of delivery when advantages were named, and they tended to identify problems they encountered with the microfiche when they considered the disadvantages. For example:

  --you don't lose your place (N=3)
  --the information is big enough to look at and work too (N=3)
  --more interesting--less tiring (N=3)
  --easier to find information (N=3)
  --it's more specific (N=1)
  --don't have to flip through the pages to find something (N=3)
  --easier access to lessons (N=1)
  --quicker, less space, more compact (N=9)
  --pictures are clearer (N=7)
  --less money (N=1)
  --in front of you--stares you in the eye (N=2)
  --easier to read (N=4)

  --not as quick (N=2)
  --pictures not clear enough--blurry (N=5)
  --reader takes up too much space (N=3)
  --cannot take it home (N=7)
  --hard to keep clean (N=3)
  --focus (N=2)

Sixteen students indicated that there were not any disadvantages with the system, and four students failed to find any advantages. Two of these students indicated that they preferred the Illustrated Text, and one recommended against broader use of the microfiche.

During the later portion of the trial, students used microfiche sets that were made up of both versions of the Block 14 lessons. Two fiche in a set (either the first two or the last two fiche) were Version I--Progressive Sequence, and two fiche were formatted according to Version II--Full Frame. The objective of combining the two versions in a set was to make it possible for students to report their preference for a particular version and to comment on why that version was preferred. Twenty-three students were involved in this phase of the trial. The 21 students using the system during the first phase of the trial worked with only Version I--Progressive Sequence.

Approximately one-fourth of the students (26 percent) attempted to articulate relative advantages of each version and identified advantages of both; one-third of the students (35 percent) preferred Version I, while three students (13 percent) preferred the Full Frame Version. The rest of the students (26 percent) either found no difference between versions or made no attempt to comment. The significance in these results lies in the fact that the two different fiche formatting principles were recognized by 74 percent of the students and that their indications of a preference confirmed the reality of the basic problem addressed during this project, i.e., how to most effectively integrate text with visual content on microfiche. As discussed previously, the main difference between the two versions of the microfiche concerned the way a balance was struck between the text and pictorial content of the microfiche. The text was identical and the total number of illustrations presented was essentially the same for each version: only the relationship between text and illustrations changed. The students' sensitivity to these issues can be gauged from Table 4 where four student responses, representing the four categories of preference noted above, have been tabulated. Student responses to the other questions have been included to provide insight into each student's experience.

Conclusions

The results of the Block 14 Trial should be analyzed from several different viewpoints. First, it is clear that the Dual-Fiche concept is a practical one. Refinements such as employing a clear, disposable envelope for registering the two fiche and protecting the film represent logical improvements in the instructional materials. Second, the bulk of the problems encountered during student use can be solved through careful and systematic implementation. Such things as window glare, type-size, machine performance (focus, bulk, screen size, etc.), work space, student orientation, film handling, and so on, can be addressed in a comprehensive system design. Third, the need for an update capability, as is represented by the Dual-Fiche, was reinforced. The instructors had strong (and highly personalized) views about the adequacy of the instructional content of both the microfiche and the illustrated text. Fourth, the microfiche can be used to deliver color-based, visually intensive instruction within a performance-oriented environment.

TABLE 4. REPRESENTATIVE RESPONSES TO THE QUESTION OF MICROFICHE FORMAT AND OTHER COMMENTS

Question: (A, B, etc., identify the responses of a particular student to each question.)

- Did you notice that the first two microfiche you used were different from the last two microfiche? We made two versions of the lessons and we need to know if you think one version is better than the other.

  The version (Full Frame) with the pictures that filled the screen was better because:

  A--It gave a little more detail on the object I was soldering.
  B-- --
  C--It showed more than words, it really helped.
  D--Noted no difference.

  The version (Progressive Sequence) with the text beside each picture was better because:

  A--You could reference back to the paragraph to do the work more efficiently.
  B--It explained more clearly, the text helped clarify the picture.
  C-- --
  D--Noted no difference.

- After you had completed lesson 1 and 2, was the way the lessons were organized on the film clear to you?

  A--Yes, I caught on after the second column on the first fiche.
  B--Yes.
  C--Yes, they were very easy to learn.
  D--The first few lessons were easier to understand than later lessons.

- Did you have any problems in using the reader or changing the microfiche?

  A--No, none at all (small model reader).
  B--It was hard to read at times (small reader).
  C--No, it was a very simple operation (large reader).
  D--Got it upside-down most of the time.

TABLE 4. REPRESENTATIVE RESPONSES TO THE QUESTION OF MICROFICHE FORMAT AND OTHER COMMENTS (CONT.)

- Was dust or dirt on the microfiche a problem?

  A--No, it was hardly noticeable.
  B--No.
  C--No, it was very clear.
  D--There was no dust or dirt at all.

- Was the presence of the TO information on the film helpful to you?

  A--Yes, it explained in detail what I was seeing on the film.
  B--Yes.
  C--Yes.
  D--Yes, much easier than going to the (Actual) TO

- Should the type-size of the text be made larger?

  A--It all depends on the person, I think; but personally I don't think so.
  B--Yes, a little.
  C--No, they are just the right size.
  D--No, it was easy to read.

- Would you compare using the microfiche system to using Illustrated Texts?

  Advantages:

  A--A lot more interesting than using a book.
  B--Easier to learn by--less tiring.
  C--It took up less space, more convenient.
  D--The illustrations are larger and it is easier to see what is going on.

  Disadvantages:

  A--You have to focus during your lesson.
  B--Harder to read.
  C--I couldn't find any.
  D--Sometimes the pictures seem to be blurred.

- Please make any suggestions that you think would improve the microfiche system.

  A--A self-focusing lens and mechanized way of moving the film would help a lot.

TABLE 4. REPRESENTATIVE RESPONSES TO THE QUESTION OF MICROFICHE FORMAT AND OTHER COMMENTS (CONT.)

B--At times the machine was hard to read. On side of the screen was in focus while the other side was not. The machine is less fatiguing especially in the early morning hours. But the sun glare is a major drawback in reading the machine.

C--More of a detailed description of the subject matter would be helpful.

D--A better system to file the films. Have a title on them so you know which one to go to.

V. RECOMMENDATIONS

The recommendations presented in this section are strongly influenced by the favorable cost-of-production picture associated with the Dual-Fiche concept. Table 5 has been developed to give an elementary picture of the production costs for the two versions of the Dual-Fiche. As a point of reference, the AIS production cost experience for prenarrated filmstrips is also presented.

The assumptions made in developing the comparison are that:

- 25 copies of the module are produced.
- The costs of preparing the script, storyboard, and obtaining 35mm exposures of illustrations and flat art (total person-hours/hour of instruction) are the same.
- The costs of capital equipment--cameras, audio reproduction equipment, the computer and computer terminal--are not allocated.
- Each frame of visual information has audio or text associated with it.

The table shows how the marginal costs accrue when the number of images, with either text or audio narration, is increased from 25 images to 75 images per module. The maximum number of visuals that can be expected on a single fiche is approximately 100. The formatting of the fiche by column indicates that the film capacity will be underutilized. For purposes of the comparison, it has been assumed that the color fiche would have a maximum of 75 frames or images. The marginal cost patterns are shown in Figure 5. The table also provides a basis for estimating the costs of updating text and audio, assuming that the visual component is revised and that the updating makes small but important changes. It also demonstrates the potential for updating the visual component alone.

Updating the audio component of a filmstrip, assuming that the cassettes are reused, involves labor costs primarily, and these costs are estimated at $9.00 for 25 frame lessons and $18.00 for 75 frames. The cost to update the text in either version via COM is also about $9.00 for 25 frames, but it is the same for 75 frames. To update the visual component, 25 frames of filmstrip (assuming A&B roll printing with the updated frames on the B roll) would cost approximately $25.00 for 25 frames and approximately $80.00 for 75 frame modules. The color fiche could be updated for approximately $60.00; again the cost is essentially independent of the number of frames in the module. In considering the implications of these comparisons, it is important to note that the cost of the color fiche component has been estimated at $2.00 per copy. This cost could decrease sharply, i.e., to $1.25 range, if a system for duplicating masters were assumed.

TABLE 5. PRODUCTION COST COMPARISON FOR DUAL-FICHE VERSIONS:
AIS PRODUCTION COSTS FOR FILMSTRIPS INCLUDED FOR REFERENCE

Cost Categories	Prenarrated Filmstrip		Version I--Prog. Sequence		Version II--Full Frame	
	25 Frames	75 Frames	25 Frames	75 Frames	25 Frames	75 Frames
Processing Original Negative	3 ft @ $0.30=0.90	$ 2.70	3 ft @ $0.30=0.90	$ 2.70	3 ft @ $0.30=0.90	$ 2.70
Enlarging to 2.5" x 3"					$25 @ $1.50=37.50	$112.50
Enlarging to 6" x 8"	$25 @ $3.00=75.00	$225.00				
Filmstrip Master Neg.	3 ft @ $0.10=0.30	$ .90				
$6.00/hr Labor	1/4 hr/25 Frames= $1.50	$ 4.50				
Internegative Processing	3 ft @ $0.30-0.90	$ 2.70				
3 Density Prints	3 ft @ $0.15=0.45	$ 1.35	3 ft @ $0.15-0.45	$ 1.35		
Kotalith Masks & Processing			2 @ $1.00=2.00	$ 2.00		
Strip-up and Paste-up			2 hr/25 Frames= $12.00	$ 36.00	2 hr/25 Frames= $12.00	$ 36.00
Ektachrome Prints & Processing			25 @ $2.00=50.00	$ 50.00	25 @ $2.00=50.00	$ 50.00
$6.00/hr Labor			25 Fiche/hr=6.00	$ 6.00	50 Fiche/hr=3.00	$ 3.00
Filmstrip Print	75 ft @ $0.30= $22.50	$ 67.50				
Audio Recording (Total) Labor	2 hr/25 F=6.00	$ 18.00				
Labeling & Packaging Labor	50 units/hr=3.00	$ 3.00				
Packaging and Cassettes	$1.00/unit=26.50	$ 26.50	$0.10/unit=2.50	$ 2.50	$0.10/unit=2.50	$ 2.50
Fiche Reformattin Labor			1 hr/25 images= $6.00	$ 18.00	1 hr/25 images= $6.00	$ 18.00
COM Back-up Tape & Dump			$1.00/63 F=1.00	$ 1.00	$1.00/63 F=1.00	$ 1.00
COM Master Fiche			$0.85/Master=1.85	$ 1.85	$0.85/Master=1.85	$ 1.85
COM Duplicates			25 F @ $0.15=3.75	$ 3.75	25 F @ $0.15=3.75	$ 3.75
Computer Time @ $700/hr			Estimate $10.00	$ 30.00	Estimate $10.00	$ 30.00
Cost Estimates for 25 Copies	$135/25 F	$349/75 F	$97/25 F	$155/75 F	$128/25 F	$261/75 F

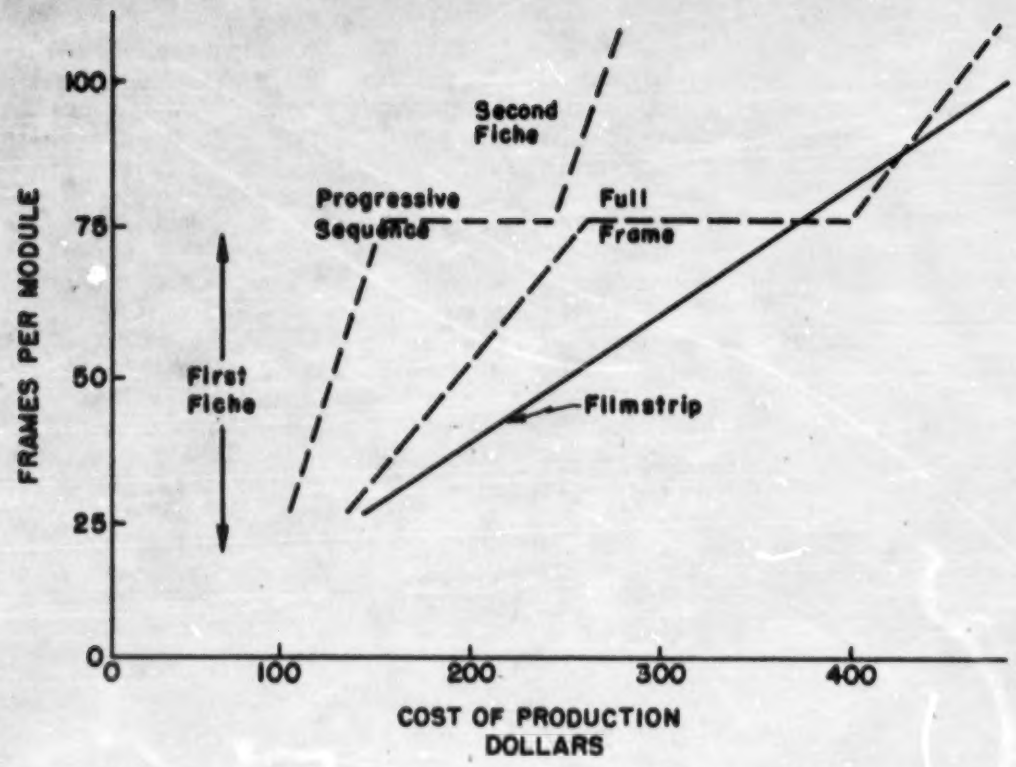


Figure 11. Marginal Cost Patterns--Dual-Fiche VS Filmstrip

Recommendations

The Dual-Fiche development reported here is believed to have great potential in meeting the multiple objectives inherent in instructional technology development. There are good reasons to believe that it can be a cost-effective alternative for delivery of visually intensive instructional modules and that it would enjoy broad student acceptance. It is an alternative to the familiar AV media when the multimedia requirement is not essential to the instructional strategy employed.

In terms of the AIS environment at Lowry AFB, or other environments in which computer-based instruction is being applied, the Dual-Fiche concept is particularly significant:

1. The concept ensures that "updating capability" is an inherent feature of microfiche-based instruction.

2. It ensures that color-intensive instruction can be delivered through the microfiche medium as well as other types of instructional materials.

3. It ensures that the production capability can be "transferred" to the course developers and Air Force production agency.

The principal recommendation is to develop the concept further. This development should take place in an instructional environment in which the refinement of techniques for producing the microfiche can

proceed at the same time that a system to support large scale use is established. By developing and evaluating instructional modules while building the capability, in terms of equipment and skilled persons to produce, modify, and update the modules, it will be possible to build the base of experience needed to foster routine use of microforms.

The starting point for implementing the recommendation might be to select a course of instruction, perhaps not a current AIS course, in which the updating of instructional modules is an urgent and recurring problem. For certain blocks of instruction in the course, instructional materials (modules) would be developed using the AIS system and the capability of an Air Force production agency. As these materials are evaluated (it would be desirable to incorporate the AIS testing capability as a part of the evaluation system), updated materials would be introduced on a regular basis, and these materials would also incorporate the improvements identified by the evaluation process. Such an environment would act as a test bed to resolve conceptual and technical issues, and as practical results are demonstrated, the capability would be present to extend the proven applications to other blocks and ultimately to other courses driven by the inherent need to modify or update course materials.

APPENDIX A

QUESTIONNAIRES USED FOR IMPLEMENTATION FEEDBACK

Microfiche Evaluation Questionniare
(For Use by the Denver Research Institute, University of Denver)

You have been using computer-generated microfiche to present your Block Test questions. We need your help in evaluating this microfiche-viewer system. Please complete this questionnaire.

1. Your Social Security Number _____

2. Which Block Test did you complete using the microfiche? _____

3. Did you have any problems using the microfiche or the viewer? ____

   Comments _____

4. Did dust or fingerprints on the microfiche cause problems? _____

   Comments _____

5. The Block Test questions were shown one-at-a-time on the viewer screen. Was this arrangement satisfactory to you? _____

   Comments _____

6. The microfiche can be made with either black print on a light background, or white print on a dark background. Which type did you use?

   Light background _____; Dark background _____

7. Please make any suggestions you think would improve the microfiche system. _____

   _____

   _____

Thank you for your help in this evaluation.

Student Evaluation of the Microfiche System
(For Use by the Denver Research Institute, University of Denver)

1. Your Instructor will show you how to operate the reader and insert microfiche in the reader.

   - o Wait for these instructions.
   - o Always handle the microfiche by their labels (at the top). (Dirt and fingerprints will impair performance.)
   - o Keep microfiche holder on top of the reader except when changing microfiche.

2. After cleanup of the work station, complete the questions below and give this sheet to your Instructor. Return the microfiche holder to the Instructor. Your comments are very important for evaluating and improving this new system.

   - o Your Social Security Number _____
   - o Did you use a large reader _____ or a small one _____?
   - o After you had completed lessons 1 & 2, was the way the lessons were organized on the film clear to you?

     Comments: _____
   - o Did you have any problems in using the reader or changing the microfiche?

     Comments: _____
   - o Was dust or dirt on the microfiche a problem?

     Comments: _____
   - o Was the presence of the TO information on the film helpful to you?

     Comments: _____
   - o Should the type-size of the text be made larger?

     Comments: _____
   - o Would you compare using the microfiche system to using illustrated texts?

     Advantages: _____

     Disadvantages: _____

- Please make any suggestions that you think would improve the microfiche system.

_____

_____

- Did you notice that the first two microfiche you used were different from the last two microfiche? We made two versions of the lessons and we need to know if you think one version is better than the other.

  The version with the pictures that filled the screen was better because _____

  _____

  The version with the text beside each picture was better because _____

  _____

Thank you for your help in the evaluation.

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